CHEMISTRY

SECTION – I

Single Correct Choice Type

This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONLY ONE is correct.

1. Benzoic acid is distributed between water and benzene. Concentration of benzoic acid in two layer are :

Conc.	I	II	III
C (in H_2O)	0.1 M	0.2 M	0.3 M
C(in benzene)	0.01 M	0.04 M	0.09 M

Hence, benzoic acid is:
(A) monomer in both layers (B) dimer in both layers
(C) monomer in water and dimer in benzene (D) monomer in benzene and dimer in water

2. Surface tension of water is 73 dyne cm^{-1} at 20°C. If surface area is increased by 0.10 m^2, work done is:
(A) 7.3 erg (B) 7.3×10^4 erg (C) 73 joule (D) 0.73 joule

3. Distribution coefficient of solute X between ether and water is 2.1g of solute X is in 100 g water. If X is extracted into ether by 100 mL of it then:
(A) 0.667 g of X is extracted into ether if it is used in one part of 100 mL
(B) 0.75 g of X is extracted into ether if it is used in two parts of 50 mL each
(C) both (A) and (B)
(D) none of the above

4. In a mole of water vapour at STP, the volume actually occupied or taken by the molecules (i.e., Avogadro's No. × Volume of one molecule) is
(A) Zero (B) Less than 1% of 22.4 litres
(C) About 10% of the volume of container (D) 1% to 2% of 22.4 litres

5. One litre hard water contains 12.00 *mg* Mg^{2+} milli equivalent of washing soda required to remove its hardness is
(A) 1 (B) 12.15 (C) 1×10^{-3} (D) 12.15×10^{-3}

6. Which alkali metal is most metallic in character?
(A) K (B) Cs (C) Na (D) Li

7. The electronic configurations of four elements are given below. Arrange these elements in the correct order of magnitude of their electron affinity
(i) $2s^2\ 2p^5$ (ii) $3s^2\ 3p^5$ (iii) $2s^2\ 2p^4$ (iv) $3s^2\ 3p^4$
Select the correct answer using the codes
(A) (i) < (ii) < (iii) < (iv) (B) (ii) < (i) < (iv) < (iii)
(C) (iii) < (iv) < (i) < (ii) (D) (iii) < (iv) < (ii) < (i)

8. Which of the following statements is/are wrong?
(A) Van der Waal's radius of iodine is more than its covalent radius
(B) All isoelectronic ions belong to same period of the periodic table
(C) IE_1 of N is higher than that of O while IE_2 of O is higher than that of N
(D) The electron gain enthalpy of N is zero while that of P is 74.3 KJ mol^{-1}

SECTION – II

Multiple Correct Choice Type

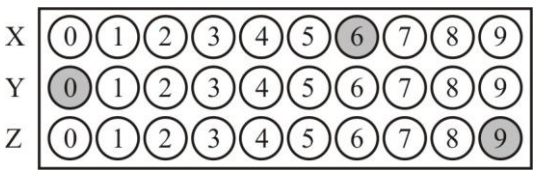
This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONE OR MORE is/are correct.

9. The statement that is correct for the periodic classification of elements is
   (A) The properties of elements are the periodic function of their atomic numbers
   (B) Non-metallic elements are lesser in number than metallic elements
   (C) The first ionization energies of elements along a period do not very in a regular manner with increase in atomic number.
   (D) For transition elements the d subshells are filled with electrons monotonically with increase in atomic number.
10. Stability of ions of Ge, Sn and Pb will be in order:
   (A) $Ge^{2+} < Sn^{2+} < Pb^{2+}$ (B) $Pb^{4+} < Sn^{4+} < Ge^{4+}$
   (C) $Sn^{2+} < Sn^{4+}$ (D) $Pb^{4+} < Pb^{2+}$
11. Equations of state of an ideal gas is/are
   (A) $pV = (1/3)mN$ (B) $pV = nRT$ (C) $p = \rho RT/M$ (D) $p = 3Nk/2V$.
12. For a fixed mass of a gas at constant pressure, which of the following statements is/are not correct?
   (A) Plot of volume versus Celsius temperature is linear with intercept zero
   (B) Plot of volume versus Kelvin temperature is linear with a non-zero intercept
   (C) Plot of V/T versus T is linear with a positive slope
   (D) Plot of V/T versus T is linear with a zero slope

SECTION – III

Integer Answer Type

This section contains 6 questions. The answer to each of the questions is a single digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y and Z (say) are 6, 0 and 9, respectively, then the correct darkening of bubbles will look like the following:

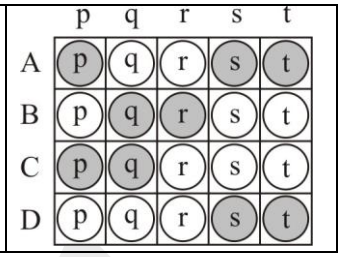


13. The ratio of the root mean square velocity of H_2 at 50 K and that of O_2 at 800 K is _____
14. The percent loss in mass of $K_2Cr_2O_7$ (molar mass Cr = 52 g mol^{-1}) on heating will be about
15. One litre of gas weighs 2 g at 300 K and 1 atm pressure. If the pressure is made 0.75 atm, and temperature is brought down to 250 K, the gas will occupy a volume of approximately ____
16. A gas pressure was recorded as 29.4 1b m^{-2}. Its value in atmospheres will be
17. The element having electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ has valency _____
18. Two gases X and Y have densities, $d_{(x)} = 3d_{(y)}$ and molecular mass, $M_{(x)} = 0.5\ M_{(y)}$. Then, the ratio of their pressures, i.e., $p_x : p_y$ would be

SECTION – IV

Matrix-Match Type

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in Column I are labelled A, B, C and D, while the statements in Column II are labelled p, q, r, s and t. Any given statement in Column I can have correct matching with ONE OR MORE statement(s) in Column II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example: If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.



19. Match the classification (in Column - I) with the element (in Column - II) :

Column – I		***Column – II***	
(A)	Alkaline earth metal	(p)	Rb
(B)	Radioactive element	(q)	As
(C)	Alkali metal	(r)	Mg
(D)	Metalloid	(s)	Fr
		(t)	Be

20. Column – II gives the values of γ (= $C_{p,\,m}/C_{V,\,m}$) at high temperature of gases which are shown in Column – I. Identify the gas with the corresponding γ value.

Column – I	***Column – II***
(A) Monatomic	(p) 1.154
(B) Diatomic	(q) 1.286
(C) Linear Triatomic	(r) 1.167
(D) Nonlinear Triatomic	(s) 1.407
	(t) 1.667

MATHEMATICS

SECTION – I

Single Correct Choice Type

This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONLY ONE is correct.

21. $S = \{(x, y) : x + y = 2, \tan x \,.\, \tan y = 1\}$, then
(A) S = R x R the set of all ordered pairs of real numbers
(B) $S = \phi$, the null set
(C) S = { (1, 1) }
(D) S has exactly two elements.

22. A college awarded 38 medals in Football, 15 in Basketball and 20 in Cricket. If these medals went to a total of 58 men and only three men got medals in all the three sports, then persons who received medals in exactly two of the three sports are
(A) 6 (B) 9 (C) 12 (D) none of these

23. If R be a relation from A = {1, 2, 3, 4} to B = {1, 3, 5} i.e. (a, b) $\in$ R iff a < b, then RoR^{-1} is
(A) {(1, 3), (1, 5), (2, 3), (2, 5), (3, 5), (4, 5)}
(B) {(3, 1), (5, 1), (3, 2), (5, 2), (5, 3), (5, 4)}
(C) {(3, 3), (3, 5), (5, 3), (5, 5)}
(D) {(3, 3), (3, 4), (4, 5)}

24. If $f(x) = \log\left(\frac{1+x}{1-x}\right)$ then

(A) $f\left(\frac{2x}{1+x^2}\right) = f(x^2)$ (B) $f\left(\frac{2x}{1+x^2}\right) = f(x)$

(C) $f\left(\frac{2x}{1+x^2}\right) = 2f(x)$ (D) $f\left(\frac{2x}{1+x^2}\right) = f(1+x)$

25. Suppose $f(x) = (x+1)^2$ for $x \geq -1$. If $g(x)$ is the function whose graph is the reflection of the graph of $f(x)$ with respect to the line $y = x$, then $g(x)$ equals

(A) $-x-1, x \geq 0$ (B) $\frac{1}{(x+1)^2}, x > -1$

(C) $\sqrt{x+1}, x \geq -1$ (D) $\sqrt{x}-1, x \geq 0$

26. If cos A + cos B = m and sin A + sin B = n where m, n $\neq$ 0 then sin (A + B) is equal to

(A) $\frac{mn}{m^2+n^2}$ (B) $\frac{2mn}{m^2+n^2}$ (C) $\frac{m^2+n^2}{2mn}$ (D) $\frac{mn}{m+n}$

27. Each student in a class of 40, studies at least one of the subjects English, Mathematics and Economics. 16 study English, 22 Economics and 26 Mathematics, 5 study English and Economics, 14 Mathematics and Economics and 2 study all the three subjects. The number of students who study English and Mathematics but not Economics is.
(A) 5 (B) 7 (C) 10 (D) 14

28. If α, β , γ are lengths of the altitudes of a triangle ABC the $\frac{1}{\alpha^2}+\frac{1}{\beta^2}+\frac{1}{\gamma^2}$ is equal to

(A) $\frac{\cot A+\cot B+\cot C}{\Delta}$ (B) $\frac{\Delta}{\cot A+\cot B+\cot C}$

(C) Δ(cot A + cot B + cot C) (D) none of these

SECTION – II

Multiple Correct Choice Type

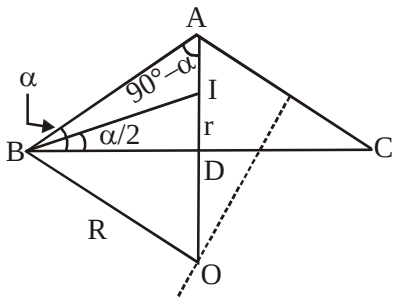
This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONE OR MORE is/are correct.

29. If A $\geq$ 0, B $\geq$ 0, A + B = $\frac{\pi}{3}$ and y = tan A. tan B then

(A) the maximum value of y is 3 (B) the minimum value of y is $\frac{1}{3}$

(C) the maximum value of y is $\frac{1}{3}$ (D) the minimum value of y is 0

30. Given an isosceles triangle with equal sides of length b, base angle $\alpha < \pi/4$, R, r the radii and O, I the centres of the circumcircle and incircle, respectively. Then



(A) $R = \frac{1}{2} b \operatorname{cosec} \alpha$ (B) $\Delta = 2b^2 \sin 2\alpha$

(C) $r = \frac{b \sin 2\alpha}{2(1+\cos\alpha)}$ (D) $OI = \left| \frac{b\cos(3\alpha/2)}{2\sin\alpha\cos(\alpha/2)} \right|$

31. For the expression $6\cos\theta - 8\sin\theta + 4$, $(\theta \in R)$

(A) The maximum value is 14 (B) The maximum value is 10

(C) The minimum value is –6 (D) The minimum value is –14

32. If in a triangle ABC, a, b, c are in A.P. and p_1, p_2, p_3 are the altitudes from the vertices A, B, C respectively then

(A) sin A, sin B, sin C are in A.P. (B) sin A, sin B, sin C are in H.P.

(C) $p_1 + p_2 + p_3 \le \frac{3R}{\Delta}$ (D) $\frac{1}{p_1} + \frac{1}{p_2} + \frac{1}{p_3} \le \frac{3R}{\Delta}$

SECTION – III

Integer Answer Type

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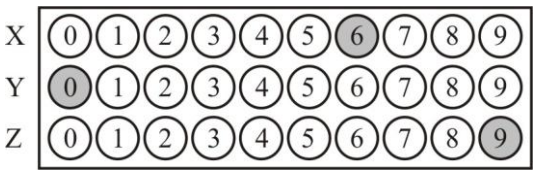

33. Let S be the set of integers which are divisible by 5, and let T be the set of integer which are divisible by 7. The number of positive integers less than 1000 and not in $(S \cup T)$ is N. Find $\frac{N}{98}$.

34. Let x, y, z be real numbers such that $\cos x + \cos y + \cos z = 0$ and $\cos 3x + \cos 3y + \cos 3z = 0$ then find the maximum value of $\cos 2x \cos 2y \cos 2z$.

35. The number of elements in the set $\{(a, b) : 2a^2 + 3b^2 = 35, a, b \in Z\}$, where Z is the set of all integers, is ____

36. Tangents parallel to the three sides of ΔABC are drawn to its incircle. If x, y, z be the lengths of the parts of the tangents within the triangle (with respect to the sides a, b, c) then find the value of $\frac{x}{a}+\frac{y}{b}+\frac{z}{c}$.

37. Let $R = \{x, y : x^2 + y^2 \le 144 \text{ and } \sin(x + y) \ge 0\}$. And S be the area of region given by R, then find $S/9\pi$.

38. If in a triangle ABC, $a >$ max. $\{b, c\}$ and two of its sides are $\sin\theta + \cos\theta$, $\sin\theta - \cos\theta$where $\theta \in \left(\frac{\pi}{4}, \frac{3\pi}{4}\right)$ & its third side lies in the solution set of $(x-\sqrt{2})(x^3-\sqrt{2}x^2+x-\sqrt{2}) \le 0$. Then angle A is π/X Find the value of X. (where a, b, c are sides of ΔABC)

SECTION – IV

Matrix-Match Type

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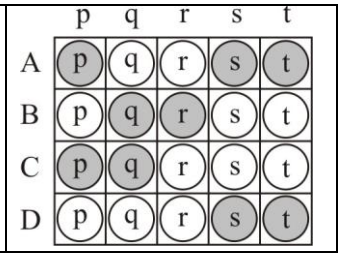


39. Match the following

	Column-I	***Column-II***
(A)	Let A = {1, 2, 3}, the total number of distinct relations that can be defined over A is	(p) ϕ
(B)	The set $A = \{x : x \in R, x^2 = 16 \text{ and } 2x = 6\}$ equals	(q) 2
(C)	Let $A = \{x \mid x^3 \le 27 \wedge x \in Z^+\}$, then Card (A)	(r) 3
(D)	Let A = Z, B = N , C = all grains in the desert, D = {2, 4, 6, 8, ...}, $E = \{x \mid x^3 \ge 27 \wedge x \in Z\}$ $F = \{x \mid x^3 \ge 27 \wedge x \in R\}$. How many of these sets are equal in cardinality (no. of elements)	(s) 2^9
		(t) 5

40. Column – I contains units and Column – II contains the physical quantities.

	Column-I	***Column-II***
(A)	$\max_{\theta \in R}$ {5 sin θ + 3sin (θ – α) then the set of possible values of α is	(p) $x = 2n\pi + 3\pi/4, n \in Z$
(B)	$x \ne \frac{n\pi}{2}$ and $(\cos x)^{\sin^2 x - 3\sin x + 2} = 1$	(q) $x = 2n\pi \pm \frac{\pi}{3}; n \in Z$
(C)	$\sqrt{(\sin x)} + 2^{1/4}\cos x = 0$	(r) $2n\pi + \cos^{-1}(1/3), n \in Z$
(D)	$\log_5 \tan x = (\log_5 4)(\log_4(3 \sin x))$	(s) no solution

(t) $2n\pi,\ n \in z$

PHYSICS

SECTION – I

Single Correct Choice Type

This section contains 8 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONLY ONE is correct.

41. The length of the side of a square sheet of metal is increasing at the rate of 4 cm/s. The rate at which the area of the sheet is increasing when the length of its side is 2 cm, is

(A) 16 cm^2/s (B) 8 cm^2/s

(C) 32 cm^2/s (D) None of these

42. The value of $\int \frac{\sqrt{(x^2 - a^2)}}{x} dx$ will be

(A) $\sqrt{(x^2 - a^2)} - a \tan^{-1}\left[\frac{\sqrt{(x^2 - a^2)}}{a}\right]$ (B) $\sqrt{(x^2 - a^2)} + a \tan^{-1}\left[\frac{\sqrt{(x^2 - a^2)}}{a}\right]$

(C) $\sqrt{(x^2 - a^2)} + a^2 \tan^{-1}\left[\sqrt{x^2 - a^2}\right]$ (D) $\tan^{-1} x/a + c$

43. Two paper screens *A* and *B* are separated by 150 *m*. A bullet pierces *A* and *B*. The hole in *B* is 15 cm below the hole in *A*. If the bullet is traveling horizontally at the time of hitting *A*, then velocity of the bullet at *A* is ($g = 10\ ms^{-2}$)

(A) $100\sqrt{3}$ m/s (B) $200\sqrt{3}$ m/s

(C) $300\sqrt{3}$ m/s (D) $500\sqrt{3}$ m/s

44. If the velocity (V), acceleration (A) and force (F) are taken as fundamental quantities instead of mass (M), length (L) and time (T), the dimensions of Young's modulus (Y) would be

(A) FA^2V^{-4} (B) FA^2V^{-5}

(C) FA^2V^{-3} (D) FA^2V^{-2}

45. A spherical body of mass *m* and radius *r* is allowed to fall in a medium of viscosity η. The time in which the velocity of the body increases from zero to 0.63 times the terminal velocity (*v*) is called time constant (τ). Dimensionally, τ can be represented by

(A) $\frac{mr^2}{6\pi\eta}$ (B) $\sqrt{\left(\frac{6\pi mr\eta}{g^2}\right)}$

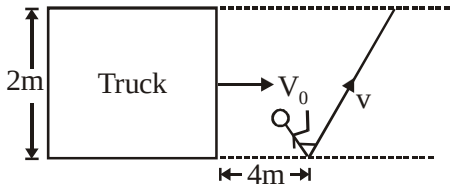
(C) $\frac{m}{6\pi\eta rv}$ (D) None of these

46. If *P* represents radiation pressure, *c* represents speed of light and *Q* represents radiation striking unit area per second, then non-zero integers *x*, *y*, and *z* such that $P^xQ^yc^z$ is dimensionless are

(A) $x=1, y=1, z=-1$ (B) $x=1, y=-1, z=1$

(C) $x=-1, y=1, z=1$ (D) $x=1, y=1, z=1$

47. A 2m wide truck is moving with a uniform speed v_0 = 8 m/s along a straight horizontal road. A pedestrian starts to cross the road with a uniform speed v when the truck is 4 m away from him. The minimum value of v so that he can cross the road safely is



(A) 2.62 m/s (B) 4.6 m/s

(C) 3.57 m/s (D) 1.414 m/s

48. The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where *a* and *b* are constants and *x* and *y* are respectively horizontal and vertical distances of the projectile from the point of projection. The maximum height attained by the particle and the angle of projection from the horizontal are

(A) $\frac{b^2}{2a}, \tan^{-1}(b)$ (B) $\frac{a^2}{b}, \tan^{-1}(2b)$

(C) $\frac{a^2}{4b}, \tan^{-1}(a)$ (D) $\frac{2a^2}{b}, \tan^{-1}(a)$

SECTION – II

Multiple Correct Choice Type

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D) for its answer, out of which ONE OR MORE is/are correct.

49. Given two vectors $\vec{A}=3\hat{i}+4\hat{j}$ and $\vec{B}=\hat{i}+\hat{j}$. θ is the angle between $\vec{A}$ and $\vec{B}$. Which of the following statements is/are correct ?

(A) $|\vec{A}|\cos\theta\left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right)$ is the component of $\vec{A}$ and $\vec{B}$.

(B) $|\vec{A}|\sin\theta\left(\frac{\hat{i}-\hat{j}}{\sqrt{2}}\right)$ is the component of $\vec{A}$ perpendicular to $\vec{B}$.

(C) $|\vec{A}|\cos\theta\left(\frac{\hat{i}-\hat{j}}{\sqrt{2}}\right)$ is the component of $\vec{A}$ along $\vec{B}$.

(D) $|\vec{A}|\sin\theta\left(\frac{\hat{i}-\hat{j}}{2}\right)$ is the component of $\vec{A}$ perpendicular to $\vec{B}$.

50. A projectile is fired with a constant speed at two different angles of projection, say, α and β, that give it the same range. The, α and β are such that

(A) cosec α = sec β (B) tan $(\alpha + \beta) \to \infty$

(C) $\sin^2 \alpha - \cos^2 \alpha = \sin^2 \beta - \cos^2 \beta$ (D) cot α = cos α sec β

51. The displacement x of a particle varies with time according to the relation $x = \frac{a}{b}\left(1 - e^{-bt}\right)$. Then

(A) At t = 1/b, the displacement of the particle is nearly (2/3) (a/b)

(B) The velocity and acceleration of the particle at t = 0 are a and $-ab$ respectively

(C) The particle cannot reach a point at a distance x' from its starting position if $x' > a/b$

(D) The particle will come back to its starting point as $t \to \infty$

52. If $\int_a^b \frac{f(x)}{f(a) + f(a+b-x)}\,dx = 10$, then

(A) b = 22, a = 2 (B) b = 15, a = –5

(C) b = 10, a = –10 (D) b = 10, a = –2

SECTION – III

Integer Answer Type

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X	0	1	2	3	4	5	**6**	7	8	9
Y	**0**	1	2	3	4	5	6	7	8	9
Z	0	1	2	3	4	5	6	7	8	**9**

53. A point moves in a straight line during the time t = 0 to t = 3 according to the law $s = 15t - 2t^2$. The average velocity is _____

54. A balloon is at a height of 40 m and is ascending with a velocity of 10 ms^{-1}. A bag of 5 kg weight is dropped from it. When will the bag reach the surface of the earth? Given g = 10 ms^{-2}.

55. The position vector of a particle is given as $\vec{r} = (t^2 - 4t + 6)\hat{i} + t^2\hat{j}$. The time after which the velocity vector and acceleration vector becomes perpendicular to each other is equal to_____sec.

56. The heat dissipated in a resistance can be obtained by the measurement of resistance, the current and time. If the maximum error in the measurement of these quantities is 1%, 2% and 1% respectively, the maximum error in the determination of the dissipated heat is ___%.

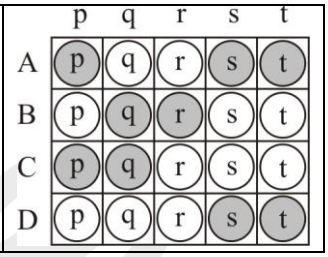
57. A car starts from rest and again comes to rest after travelling 200m in a straight line. If its acceleration and deceleration are limited to 10 m/s^2 and 20 m/s^2 respectively then minimum time the car will take to travel the distance is $x\sqrt{15}s$. Find the value of x.

58. River is flowing with a velocity $\vec{v}_R = (4\hat{i})m/s$. A boat is moving with a velocity $(-2\hat{i} + 4\hat{j})m/s$ relative to river. The width of river is 800 m along y direction. The drift of boat is $x \times 100$m. Find the value of x.

SECTION – IV

Matrix-Match Type

This section contains 2 questions. Each question contains statements given in two columns, which have to be matched. The statements in Column I are labelled A, B, C and D, while the statements in Column II are labelled p, q, r, s and t. Any given statement in Column I can have correct matching with ONE OR MORE statement(s) in Column II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example: If the correct matches are A – p, s and t; B – q and r; C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.



59. Match the following :

Column-I	*Column-II*
(A) Constant positive acceleration	(p) Speed may increase
(B) Constant negative acceleration	(q) Speed may decrease
(C) Constant displacement	(r) Speed is zero
(D) Constant slope of *a-t* graph	(s) Speed must increase
	(t) Speed must decrease

60. Using significant figures, match the following :

Column-I	*Column-II*
(A) 0.12345	(p) 5
(B) 0.12100 cm	(q) 4
(C) $47.23 \div 2.3$	(r) 1
(D) 3×10^8	(s) 2
	(t) 6

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